# THE GAS ENGINE.

HOW TO MAKE
AND USE IT.

WARWICK.

# THE

# Gas Engine

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BY B. P. WARWICK.

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## How to Make And Use It.

### CHAPTER I.

### History of the Gas Engine.

The gas engine is one of the wonders of the 19th century. Now, within three years of the 20th century, it is a novel machine, eagerly sought by many people. It is thought by persons who have not studied its principles that it is a steam-engine, using gas or gasoline as fuel for the purpose of making steam. This is erroneous. Gas and gasoline in specific proportion with air are explosive material.

The expansive force derived from explosion of these materials in the cylinder is the force that is substituted for the expansive force of steam. Hence, owing to the economy of this method as a means of deriving power, the steam engine and boiler are fast disappearing, and the Gas Engines taking their place for small power.

It is not generally known that the conception of the gas engine for the production of motive power antedates that of the steam engine. Nevertheless such is the case. It was not until the year 1744 that James Watt ran his first successful steam engine at the Soho Works, Birmingham, England, while Huyghens, Papin and other scientists had produced power in the seventeenth century by the explosion of chemicals and the expansive force of heated vapors. But the mechanical difficulties proved too great, and so little was known in that age of economical methods of producing gas as fuel for the production of heat, that when the apparently more simple method of using the expansive force of steam produced by the evaporation of water by heat produced by the combustion of coal or wood was discovered, and Watt constructed his engine for utilizing steam, all further efforts in the direction of producing power by other heated vapors were suspended. For a century and a half the intelligence and genius of the world have been expended in improving the steam engine, until it is now conceded that it is as perfect as human effort can make it. No further economy in producing power by this method can be accomplished.

After careful and intelligent tests by experts with the best instruments made at the present day, it is generally admitted that what is now deemed the perfect steam engine does not convert more than 10 per cent. of the heat efficiency into indicated work, and that ordinary engines and boilers do not realize over 4 per cent.

From 85 to 96 per cent of energy is lost in the wasteful methods of producing steam through a boiler, and the condensation and friction in conveying it to the piston of the engine where the energy is expended in work. Compare this with the effective energy produced by the expansive force of heated vapor produced by the combustion of gas in the cylinder of the engine, without any intervening throttling by friction, cooling and condensation. We have immediately gained from 10 to 20 per cent. of effectual energy from the heat units produced.

A century elapsed after the experiments of Huyghens in 1680, and Papin in 1690, before any further improvement or experiments are recorded in this direction.

Soon after steam had been successfully used, attention was again directed to the gas engine, and we find that Robert Street obtained a patent in 1794, and Lebon in 1801. In 1823

Samuel Brown constructed a gas engine that ran a boat successfully on the Thames and a road carriage on the streets of London.

W. L. Wright in 1835, and Barnett in 1838, made several important improvements. Then come Ador, Johnson, Robinson, Reynolds, Brown, Bolton, Webb, Newton, Edington, Barsanti, and Matteucci in the order named, who lend their aid in attempts to improve the machine. But it is not until 1860 that the mechanical difficulties are surmounted and a commercial gas engine constructed. Lenoir then brought the gas engine out of the experimental stage into public use, and the Reading Iron Works Co. of the U. S. built 100 of them, and several of these engines are in use at the present time. Next in line comes Hugon in 1865, and Otto and L. Langen in 1867, followed by McGreggor, Bulkeley, Clerk, Crossley, and Bisschop and others. Many years of constant application, labor, study, and experiment, with the usual discouragements and trials, have finally culminated in bringing out an engine that equals the finest steam engine of today. It is only a matter of time when the prejudice that, as usual, exists against any innovation, the ungrounded fear of explosions and

other difficulties, will be overcome and the superiority of the gas engine over the wasteful steam engine and boiler will be established. The unsightly smoke stacks, belching forth smoke and soot, will be relegated to the scrap heap, and the iron will be used to construct more useful machines. The atmosphere of our manufacturing cities will be as clear as that of the country. The cost of producing power will be so reduced that the beggar may ride, and in the next decade the steam engine will occupy the same relative position to the gas engine that the flint and steel now do to the lucifer match, the tallow dip to the electric light, the stage coach to the bicycle, motor cycle, or the modern electric street cars, and civilization will record another grand stride toward the millennium.

Gas Engines may be divided into two types, those working without compression and those that have compression. In the former, the gas and air are drawn into the cylinder at atmospheric pressure and exploded or expanded, thus producing the power. In the latter, the mixture is first drawn into the cylinder, then compressed and later exploded. As this produces a better or more powerful explosion, the economy of gas by this method is apparent.

We will first describe a typical engine of the non-compression type, the Bisschop.

## CHAPTER II.

### The Bisschop Non-Compressing Gas Engine.

The Bisschop Engine was invented by Alexis De Bisschop in 1870 and was used mainly for small power, and although it is still made it can scarcely be called a modern gas engine. It appeared about four years after Dr. Otto and Professor Langen invented their non-compression atmospheric engine, and was intended especially to avoid the noise and recoil of the free piston, rack and clutch gear and the other defects of that motor. It belongs to what is called a mixed type. The charge of gas and air is admitted at atmospheric pressure, and the force of the explosion drives up the piston, but it is attached in a special way to the crank, and does not run free.

The pressure of the atmosphere, and the energy stored up in the fly-wheel then drive down the piston into the vacuum formed by the cooling of the gases. The action of the walls

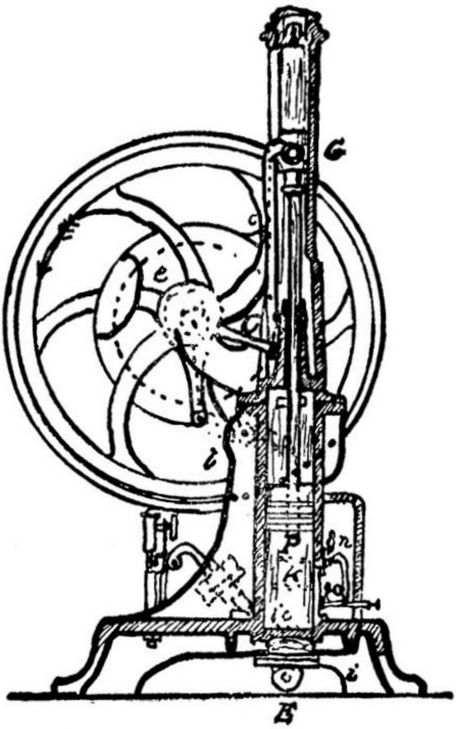



Fig 1.

Bisschop Engine
Sectional
Elevation

FIGURE I.

is here partly turned to good account, reducing the temperature of the exhaust gases and helping to form the vacuum.

In a certain sense the Bisschop, like other atmospheric engines, may be called double-

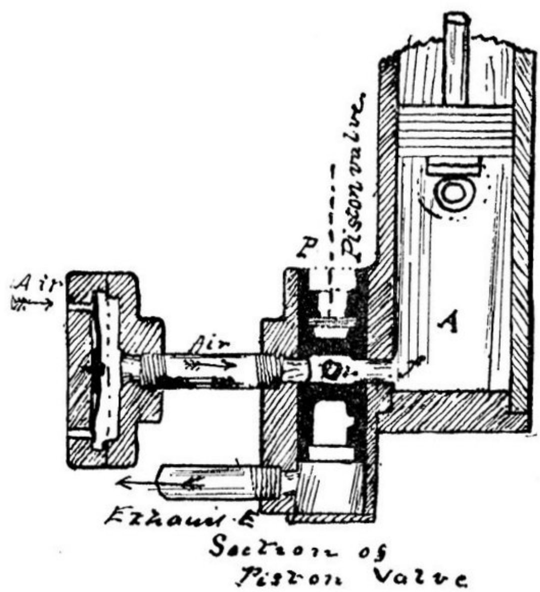



FIGURE 2.

acting. The force of the explosion being used on one side of the piston, and the pressure of the atmosphere on the other; with the exception of a few small French motors, it is probably the only non-compressing engine still in the market. It is said that about 2,000 of these engines were

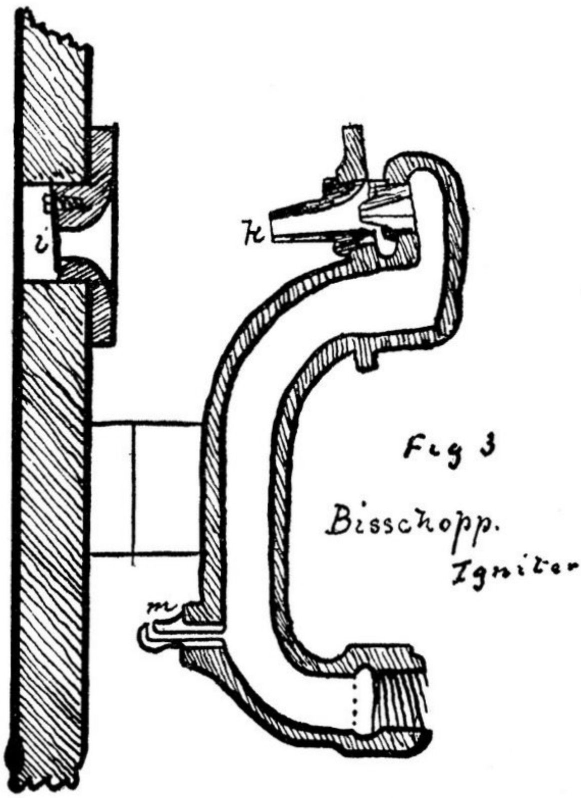



FIGURE 3.

sold in England during the first two years of their being on the market.

Like all non-compressing engines the Bisschop is not very economical, and this may be the reason why it is no longer in favor in places where the high price of gas makes economy of gas consumption a consideration.

Many cases occur, however, where simplicity and ease in starting and in handling are necessary, and here the Bisschop, which is a most convenient and simple little motor, has been found of use for small powers. For the convenience of such of our readers as desire a simple engine of this type we give a description and drawings of the Bisschop.

The engine has a vertical cylinder, closed at both ends, and the piston rod works in an upright hollow column. Above is a cross-head from which the connecting rod, working directly through the crank on the motor shaft, hangs parallel to the piston rod during the up stroke. All these parts are close to the high column carrying the piston and rod, and this causes a certain amount of vibration, but the impulse from the piston to the crank is direct.

Explosion occurs immediately after the piston has passed over the lower dead point. The

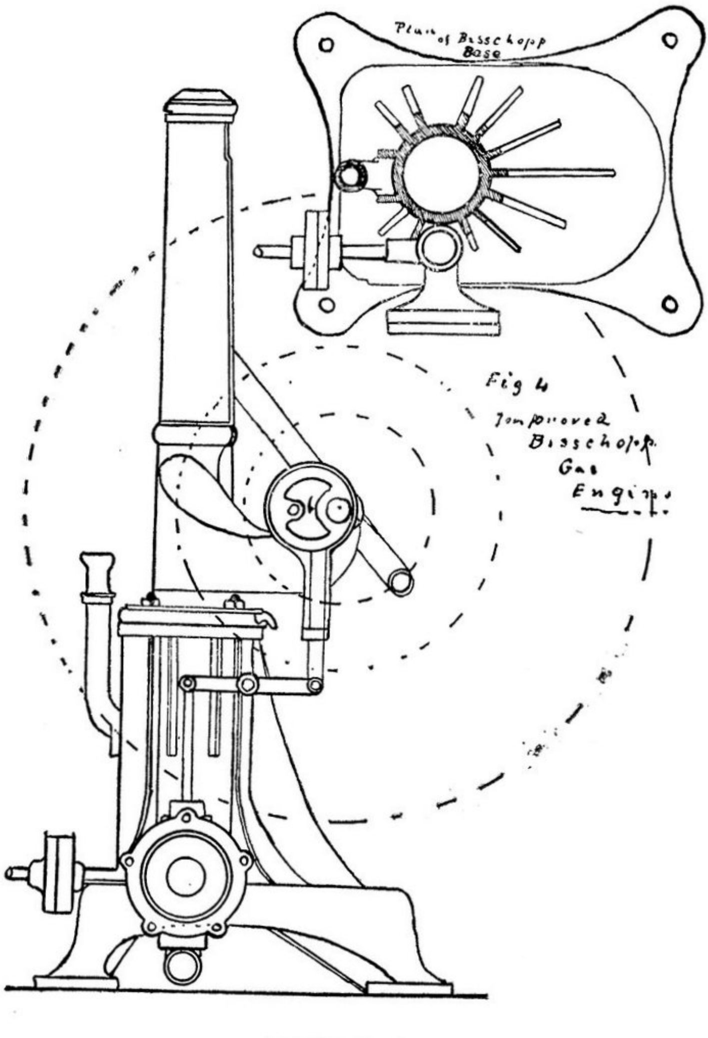



FIGURE 4.

shock forces up the piston rapidly, the crank is carried around through more than half a revolution, and the connecting rod brought parallel with the piston rod inside the column. Thus expansion is exceedingly rapid and proportionally greater than admission. The distribution of the gas and air, and the discharge of the exhaust gases, are affected by a trunk piston valve driven from an eccentric on the crank shaft. Gas and air are first admitted through valves covered with thin rubber discs. The air valve is perforated with eighteen and the gas valve with three holes admitting the charge in the proportion of six parts of air to one of gas.

The piston valve is then driven down and brought into line with the distributing chamber, and the corresponding admission port of the cylinder.

The engine has no water-jacket, the cylinder being provided externally with ribs to cool the metal. Strange to say, it not only works without oiling, but the manufacturers expressly stipulate that neither the piston nor the other parts shall be lubricated. A few drops of oil are applied occasionally to the cross-head and the motor crank only. Ignition is obtained by an external flame. The piston valve admits, dis-

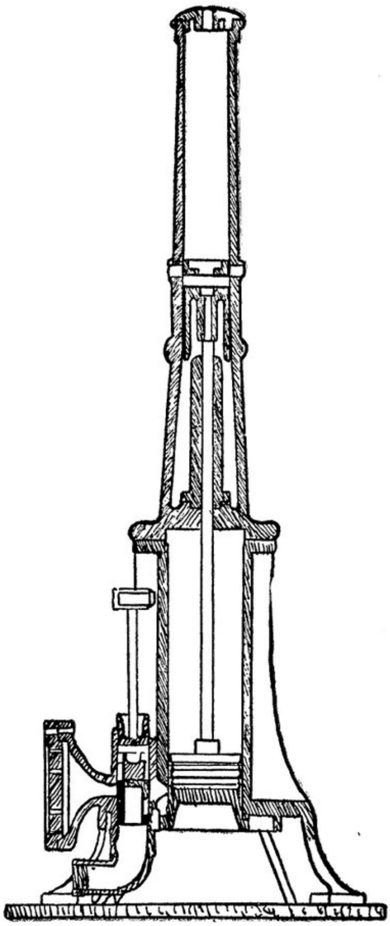


FIGURE 5.

tributes and expels the charge through the lever 1, (Fig. 1.) The exhaust is seen at E; K is the small opening about half way up the cylinder, covered by a flat valve; an external flame burns behind it at N, and at O is a second auxiliary flame, to rekindle the other when blown out. Fig. 2 shows the air valve with the holes for regulating the supply and the action of the piston valve P; the gas enters at I (Fig. 1).

*Method of Working.*—Beginning with the piston in its lowest position, when the exhaust has just been cut off, the pressure in the cylinder being below the atmosphere gas and air enter and mix in the distributing chamber. The eccentric drives down the auxiliary piston and brings its openings, M, opposite the mixing chamber and the port F into the cylinder. The charge enters, while the energy stored up in the fly-wheel carries the piston past the lower dead point. The opening at I is passed and the flat valve hanging loose before it is lifted by the vacuum, the flame is drawn in and the charge fired, explosion follows, and the pressure closes instantly the admission and igniting valves, until the piston valve, raised by the eccentric, has shut off the distributing chamber, the piston flies up with great velocity

and more energy is generated than can be utilized in the up stroke. The reserve force carries the fly-wheel through the remainder of its revolution, and drives the piston down. The exhaust valve is next open, and during the greater part of the down stroke the gases of

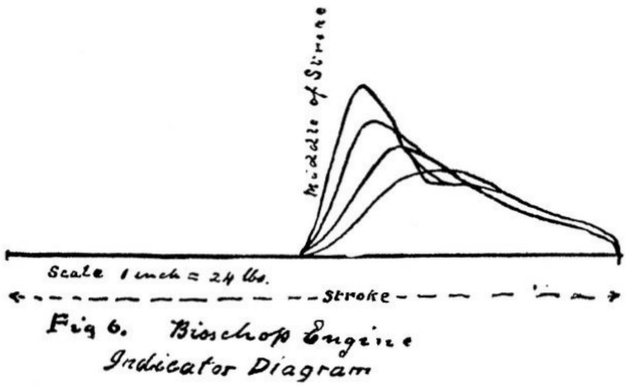



FIGURE 6.

combustion are driven out through the port uncovered by the piston valve which is now in its highest position. When the pressure in the cylinder is below atmosphere, and a vacuum has been formed, the suction lifts the rubber discs covering the gas and air admission valves, the charge enters and the cycle is repeated. The exhaust down stroke is a trifle slower than the up expansion stroke.

This engine needs no governor, the regula-

tions of the speed being effected by (2) rubber bags. The larger one acts as a reservoir and the gas passes from it into the smaller bag, which is so constructed that it receives and passes on to the cylinder exactly as much gas at a time as is required to keep the engine at any given speed.

*Test.*—Several test experiments have been carried out on this engine; all show a relatively large consumption of gas. This engine should not, however, be judged only by its expenditure of gas; neither water nor oil are required for the cylinder, and the motor is often used to replace manual labor. Its advantages disappear when the engine is made for larger powers, although the consumption of gas is proportionately diminished. In England, where it is most employed, it is seldom constructed for more than one horse power.

Fig. 6 shows a diagram or card taken from a one-horse power Bisschop Gas Engine.

## CHAPTER III.

### The Day Gas Engine.

Messrs. Day & Co., of Bath, England, have recently put upon the market an extremely simple and ingenious engine of the compression type, which, having been extensively copied with more or less modification in this country, is worthy of a short notice.

In this vertical motor several modifications from the general run of gas engines have been introduced, and although many of them have appeared in other engines, they are here utilized in a new and original way. With one cylinder only, an explosion is obtained at every revolution.

The cylinder and piston are at the top, and the latter works downward upon the crank through a connecting rod. Instead of a pump a reservoir is formed by enclosing the crank in an airtight chamber, and through a check channel or passage at the side the mixture is forced

from it into the upper part of the cylinder. With the exception of this reservoir and charging passage, the mechanism of the Day Engine is very simple. There is no counter-shaft or eccentric. The action of the piston itself

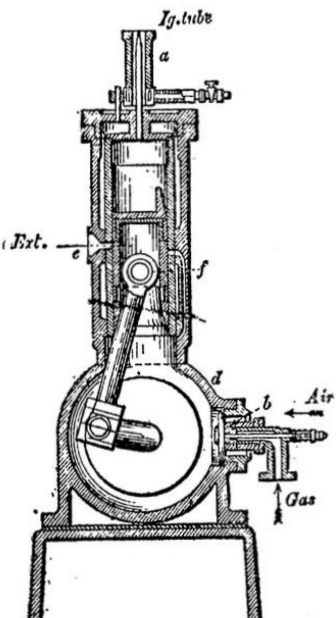



FIGURE 7.

causes the admission, explosion and discharge of the gases. There is only one valve, through which the gas and air are automatically admitted in proper proportion by the suction of the up stroke of the piston. The exhaust gases

are expelled at the same time. Ignition is by a hot tube without a timing valve, placed at the top of the cylinder. As there is an. explosion every revolution there is no danger of premature ignition, the gases being driven into the hot tube at every up stroke by the compressing action of the piston.

Fig. 7 gives a sectional elevation of a Day Gas Engine. A is the hot tube for ignition, B the automatic valve for the admission of gas and air, D is the chamber enclosing the crank, into which the charge from B is first drawn. At E is the exhaust, which is merely an opening half way down the cylinder, uncovered by the piston. F is the channel connecting the crank chamber with the working parts of the cylinder. All the four operations of the Beau de Rochas Cycle—admission, compression, explosion plus expansion, and exhaust—are performed in one up and one down stroke of the piston, the down being the motor stroke.

The action of the engine is as follows: the crank being at the lower dead point and the trunk piston at the bottom of the cylinder, its edges just clear the port opening from the channel F in the side into the upper end of cylinder. Through this channel during the

latter part of the down stroke, the fresh charge, forced out by the piston, has been passing from the reservoir D. The up stroke commences, and the port above F is immediately closed; the upper face of the piston compresses the gas and air above it, and drives them up into the ignition tube A. Meanwhile, the reservoir having been partly emptied of its contents through the side channel, a partial vacuum is formed below

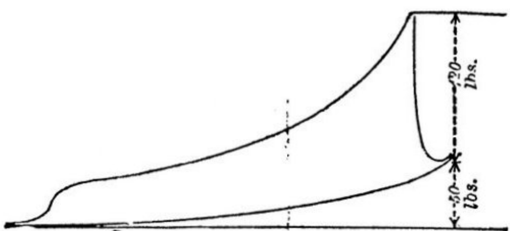



Fig. 8.—Day Engine—Indicator Diagram.

FIGURE 8.

the piston; the automatic valve B is lifted, and a fresh charge enters and fills the reservoir D. The piston having reached the end of the up stroke the charge is fired, and the expansion drives it down; the exhaust port is uncovered and the gases discharged. When the piston is through half its stroke, it begins to force the fresh charge in the reservoir below it through the side channel into the upper part of the

cylinder before the exhaust port is covered, the incoming charge, already slightly compressed, helps to drive out the products of combustion. The return stroke compresses the mixture, and the cycle recommences. The simplicity of the Day Gas Engine makes it easy to reverse its direction of rotation.

Fig. 8 gives an indicator diagram or card of a 1½ h. p. nominal engine, indicating 3.3 h. p. The diameter of the cylinder is 4½ inches, stroke 7½ inches, and it runs at 180 revolutions per minute.

## CHAPTER IV.

### The Sintz Gas Engine.

This engine, which is built by the Sintz Gas Engine Co., of Grand Rapids, Michigan, is an improvement on the Day Gas Engine of England, and is one of the few gas engines that is suitable for Electric Light Work. Owing to the excellent governor and also to its two cylinders, giving it an explosion or impulse at every half revolution, it is especially adapted to this class of work. These engines are fitted with either a hot tube or an electrical igniter, either of which gives excellent results. Fig. 9 shows a cut of this engine.

The Monitor Gas Engine and the Wolverine Gas Engine, both of which were constructed in Grand Rapids, Mich., by companies started by Mr. Clark Sintz, are both of the same type with perhaps a few modifications, as the Sintz and Day engines, and give excellent results, and are remarkably economical as to the amount of gasoline they use.

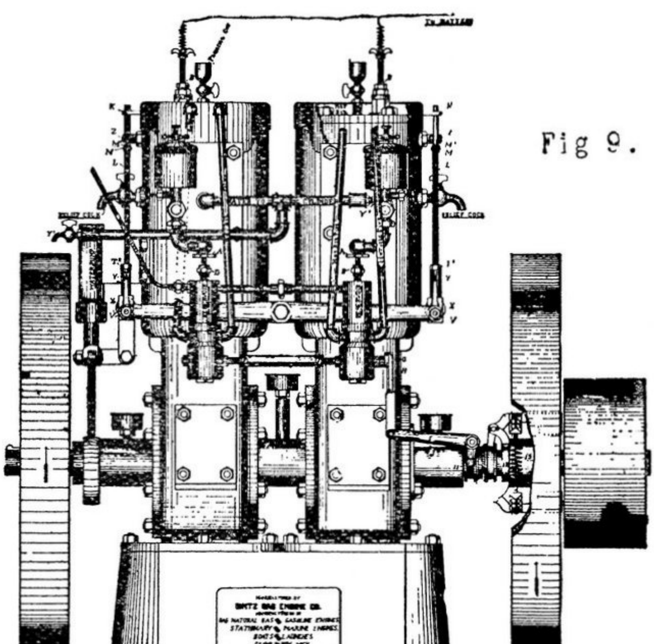


Fig 9.

FIGURE 9.

## CHAPTER V.

### The Olin Gas Engine.

The Olin Gas Engine, manufactured by the Olin Gas Engine Co., of Buffalo, N. Y., is of the four cycle type and lays claim to various novel features. Chief among these is a simplicity of construction heretofore unknown in gas engine manufacture; and a gas consumption of not more than fifteen feet per brake h. p. per hour. The charge is introduced through a piston valve-like tube, with a grinding face at end, to which gas and air suction valve is seated. The tube itself, with a self-adjusting collar and a ground seat in the valve chamber, serves as an exhaust valve, and is actuated by a cam on the main governor gear. The governor consists of two weights accurately balanced and attached to a finger, this latter engages, when the speed of the engine drops, with a dog controlling the travel of the exhaust valve, and attached to a rock lever. During accelerated speed, the finger is depressed and the dog rides on the governer disk, holding the

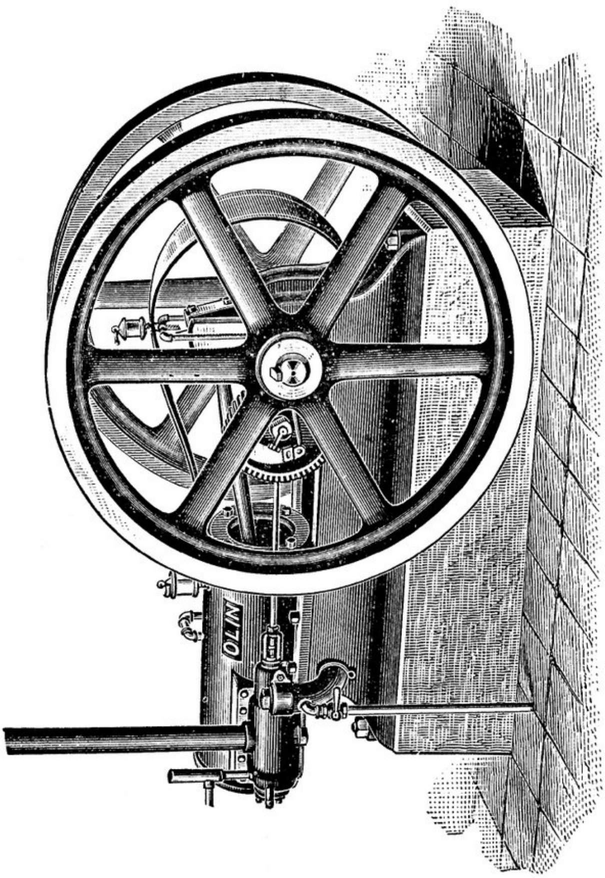



FIGURE 10.—THE OLIN GAS ENGINE.

exhaust valve open and preventing the introduction of a new charge. The construction of the governor, with its constantly moving weights, insures close regulation. The easy accessibility of every part of the completed engine is also a notable feature.

## CHAPTER VI.

### How to Make The Warwick Gas Engine.

The Warwick Gas Engine has been designed to meet the requirements of all who require a light power which is always ready and can be used as wanted. The cost and method of construction have been reduced and simplified to enable the average amateur to construct it.

The Warwick Gas Engine belongs to the class of engines exploding at constant volume with previous compression. The working cycle is that known as the Beau de Rochas Cycle, and is divided into four parts in which the engine makes two revolutions. During the first complete revolution of the engine the cylinder acts as an air pump. As the piston moves forward gas and air in the proportion of six parts of air to one of gas are admitted through the automatic inlet valve. When the piston has reached the forward or top end of cylinder the inlet valve closes, and as the piston returns

to the back end of cylinder the charge of air and gas is compressed to about one-third its original volume.

At the beginning of the second revolution the compressed charge of gas and air is ignited and exploded, either by an electric spark, a hot tube, or a flame, all of which methods are shown, it being left to the discretion of the builder as to which method is adopted.

The explosion forces the piston forward until it reaches the front or top end of the cylinder, at which time the exhaust valve opens, and during the return stroke the burnt gases are discharged through the exhaust pipe.

As will be seen, the engine receives one impulse in every two revolutions, and during the first revolution no power is developed, but on the contrary it is absorbed or destroyed, by the compression.

This, viewed from the steam engine point of view, seems on a par with the man who attempted to lift himself by his boot straps, but in spite of this apparent waste of energy, the gas engine is about three times more efficient than the steam engine.

As the working drawings are not only made to scale, but have also dimensions plainly

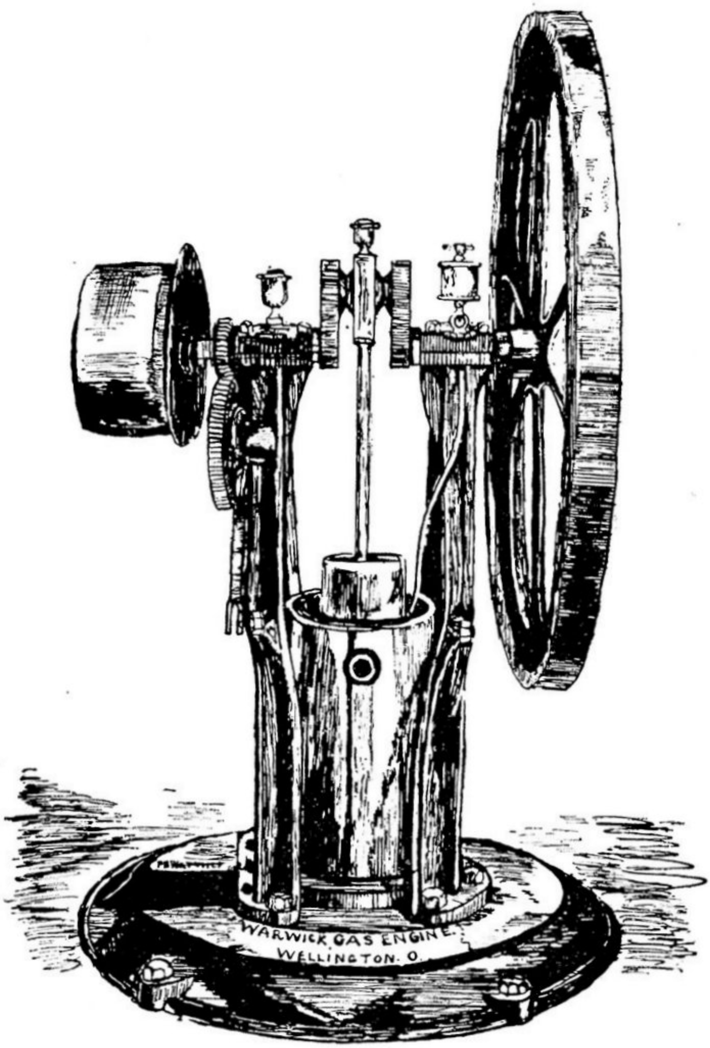



FIGURE II.—THE WARWICK GAS ENGINE.

marked in figures, there is little necessity for an extended explanation.

### GENERAL DIRECTIONS.

A few special pointers to be used in connection with the working drawings.

*The Cylinder.*—The cylinder is surrounded with a water jacket $1\frac{1}{4}$ inch thick; the ribs around the cylinder under the jacket form channels through which the water is circulated, cooling the cylinder and being finally discharged at the top.

After boring the jacket, place the cylinder on a mandrel, (having first bored the cylinder out four and a half inches) and turned down the flanges until they almost fit into the jacket; heat the jacket to a bright cherry heat and it will expand enough to pass over the flanges, and on cooling will shrink, making a tight joint.

Before shrinking on the jacket, carefully note the exact location of the bosses cast on the sides of the cylinder, these are to be drilled and tapped and $1\frac{1}{2}$ in. 10-24 screws put in to firmly hold the jacket in position; again mount the cylinder on mandrel and turn off the outside of jacket so that it will fit inside of ring in the

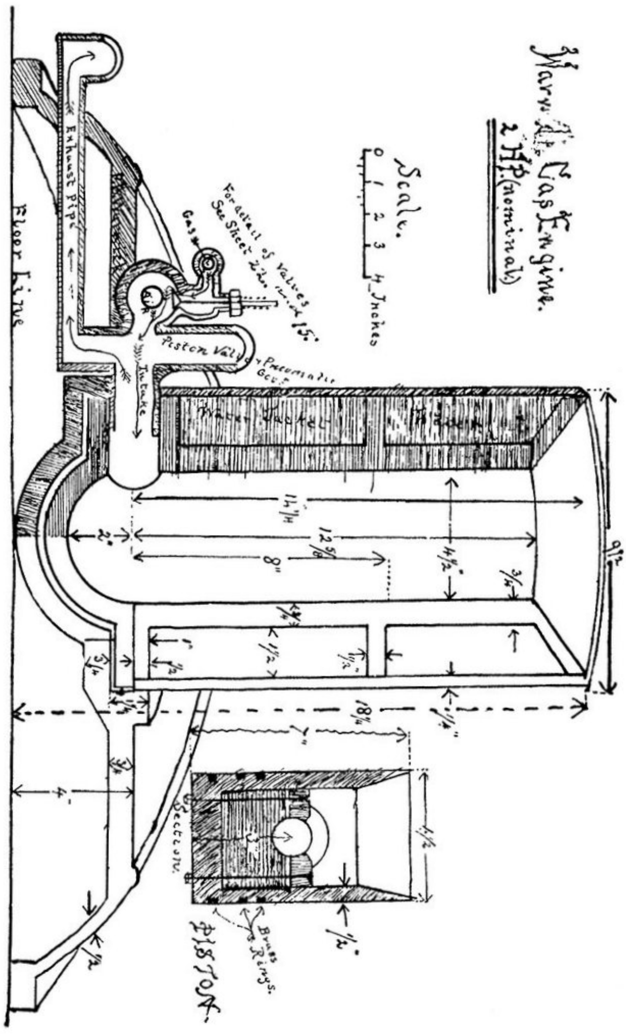

Gas Engine.
2 H.P. (nominal)
Scale.
0 1 2 3 4 Inches
Exhaust Pipe
Floor Line
Gas
Piston Valve
Intake
Water Jacket
PISTON.
Brass Rings.
Section.

FIGURE 12.

base. Now face up cylinder head both sides, and having made a good joint hold it in place with four half-inch, counter-sunk-head screws one inch long.

The cylinder is now ready to be mounted on

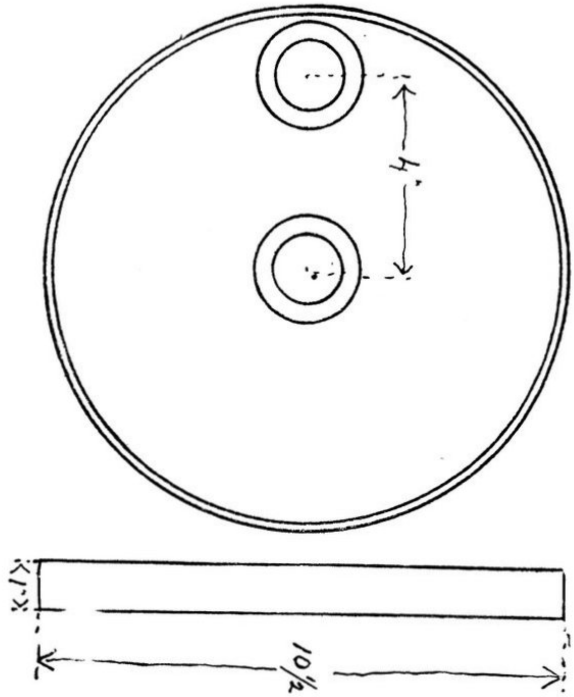



FIGURE 13.—CRANK DISK.

the base, where it should be secured with at least six half-inch cap screws. A thin layer of asbestos, or even white lead, may with advantage be placed between the cylinder head and

the base before screwing down. The exhaust and intake ports should be tapped out, and the combination valve screwed on.

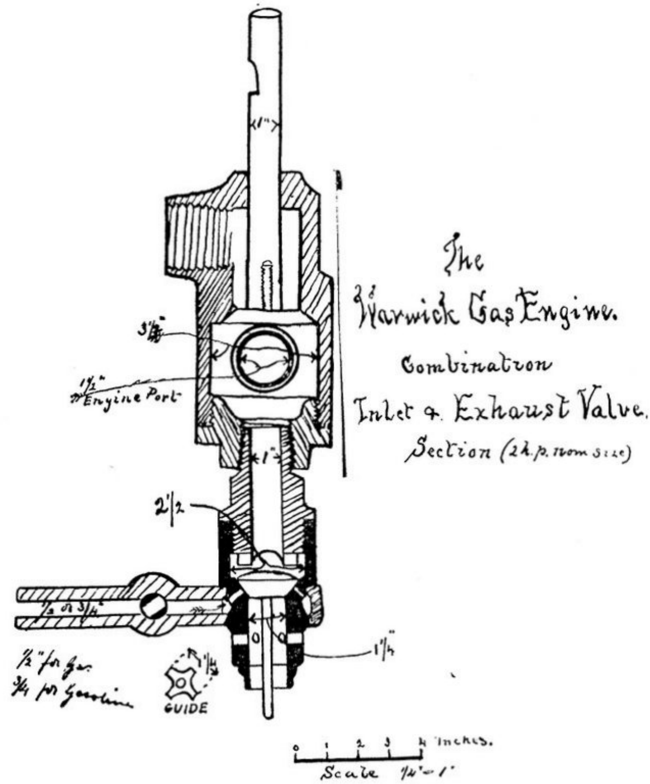



FIGURE 14.

*Valves.*—The builder here has the choice given to him of two valves, one with a pneumatic and the other with a centrifugal governor, either of which gives excellent results, but

require to be carefully made. Both exhaust, gas, and air inlet valves are made conical, and should be ground in after the yare turned to size, as a good deal depends on having tight valves if you want the engine to work successfully. The stems of both valves are of steel, and that of the exhaust valve should be hardened after the notch for the governor spindle has been cut.

*Governor.*—The action of the governor will be apparent from the working drawings. The lower end of the governing spindle should be hardened where it comes in contact with the notch cut in the exhaust valve-stem.

*Water Jacket.*—If you can make connection from a water faucet to the cooling jacket of the engine do so, or if this cannot be done a tank can be used for the water to circulate in. If, however, you intend to use the engine in a boat it will be best to make the pump shown in the drawings, and force the water in at the bottom of the jacket, as that tends to keep the cylinder cool and the water jacket full.

*Battery and Spark Coil.*—Where it is decided to use an electric ignitor, it is advisable to use a battery of three storage cells, (for preference the P. W. Dry Storage Battery) as it will not slop and has extremely high E. M. F.,

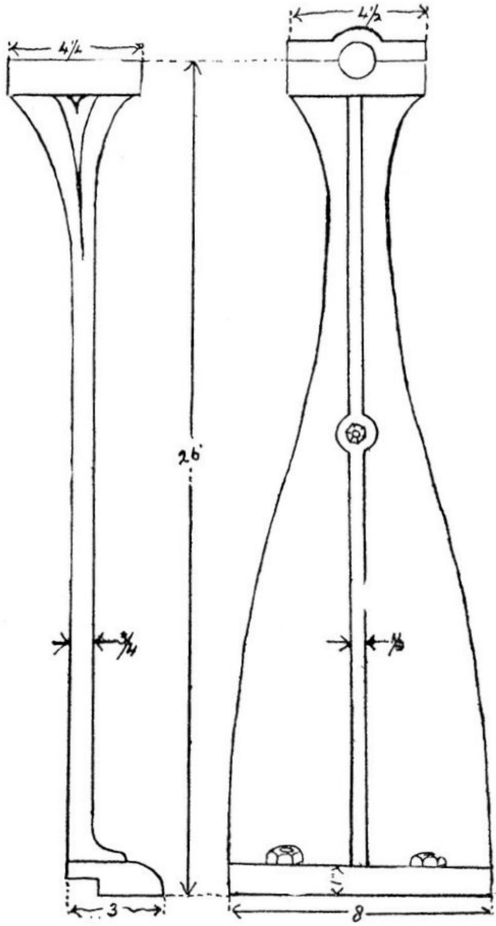



FIGURE 15.—PEDESTALS.

which tends to a fat or hot spark which is very desirable. When it is not convenient, however, to obtain these cells, almost any good, large-size carbon battery will do if you have a good spark coil. If a sal-ammoniac cell is used it is advisable to connect them, two in parallel or multiple, and say four or five in series.

The insulating bushing that passes through the cylinder head can be made of lava or porcelain as most convenient, and can be made to order by any pottery, or the lava can be obtained from the D. M. Stewart Mfg. Co., Chattanooga, Tenn.

*Carburetor.*—Where it is desirable to operate the engine with gasoline it will be necessary to have a carburetor, a sketch of which is shown and which needs no further explanation.

*Ignition Tubes.*—These may be obtained from the Fairbanks-Morse Co., from their factory at Beloit, Wis., or at one of their agencies.

## CHAPTER VII.

### The Wadsworth-Warwick Marine Gasoline Engine.

For the benefit of those of our readers who wish to use a gasoline engine for propelling a boat, drawings are given for a marine engine and to economize space a table has been prepared giving the exact dimensions of one-half, one-fourth and one h.p. engines. This table is published by permission of the Wadsworth Machine Works of Wellington, Ohio., who have given permission to use their drawings. Thinking that this hand-book will likely come into the hands of some practical machinists and engine builders who may desire to build a large size gasoline engine, scale drawings are given of a 25 h. p. (actual) engine designed by the writer several years ago in Europe and especially adapted, owing to its sensitive governor, to electric light work. Several were made to order for this purpose and have given excel-

lent results. As the drawings explain themselves to any mechanic no more need be said. This engine is called the Simplex.

## GENERAL DIMENSIONS OF STANDARD GASOLINE ENGINES.

THE WADSWORTH MACHINE WORKS.

TYPE M.

| H. P. | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/4 . . | 1/4 | 1/4 | 3/16 | 3/16 | 1 3/4 | 1 1/4 | 5 | 5/8 | 3/16 | 5/8 |
| 1/2 . . | 1/4 | 1/4 | 1/4 | 1/4 | 2 1/2 | 1 1/2 | 9 | 3/4 | 5/16 | 1 |
| 1 . . | 3/8 | 3/8 | 3/8 | 3/8 | 3 1/2 | 2 | 13 | 1 | 3/8 | 1 1/2 |
| 2 1/2 . . | 3/4 | 1 | 3/4 | 5/8 | 5 | 2 1/4 | 21 1/4 | 2 | 3/4 | 2 1/4 |

| H. P. | K | L | M | N | O | P | Q | R | S | T |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/4 . . | 1 3/4 | 2 1/4 | 1/2 | 3/8 | 13 | 8 | | 5/16 | 5/16 | 2 |
| 1/2 . . | 2 | 4 | 3/4 | 1/2 | 18 | 12 | 10 1/2 | 3/8 | 3/8 | 3 |
| 1 . . | 3 | 5 1/4 | 1 | 3/4 | 24 | 18 | 15 1/2 | 1/2 | 5/8 | 4 |
| 2 1/2 . . | 4 | 8 1/2 | 1 | 3/4 | 36 | 24 | 21 | 3/4 | 3/4 | 5 |

*The Warwick Simplex Gas Engine* is shown in Figs. 16, 17, 18 and 19. Fig. 16 being the rear end elevation showing valves, etc. These are shown again in Fig. 19. As the principal feature of this engine is its extremely simple and sensitive governor. We will give a brief description as it can be adapted to any engine.

Fig. 19 is a sectional plan and shows the

slide valve S having an admission port e leading to a mixing chamber M, to which the gas is admitted from the gas inlet g, by the spring poppet valve s, which is held closed by the

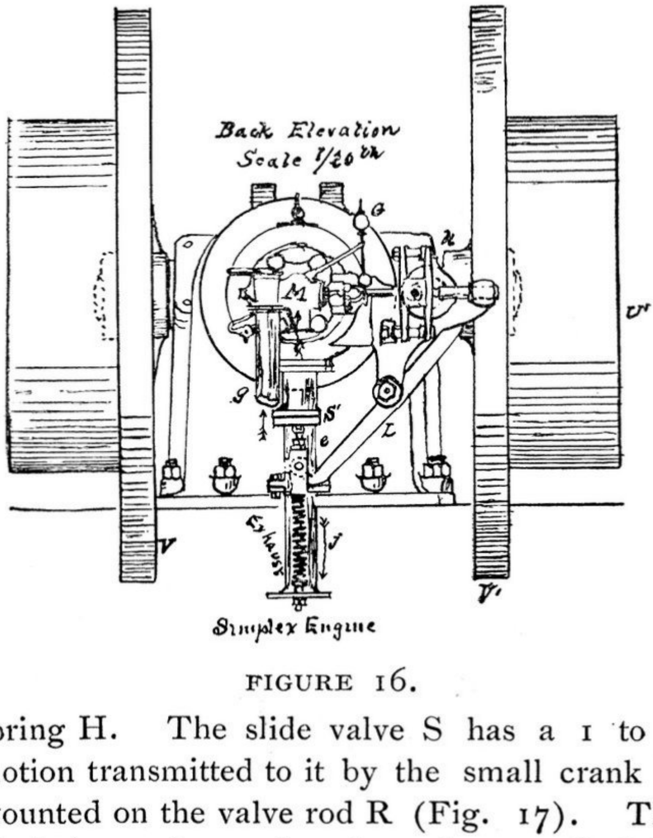



FIGURE 16.

spring H. The slide valve S has a 1 to 4 motion transmitted to it by the small crank K mounted on the valve rod R (Fig. 17). The admission and quantity of gas is controlled by the small air pump (Fig. 19) c being the cylinder in which the plunger O works. K is a

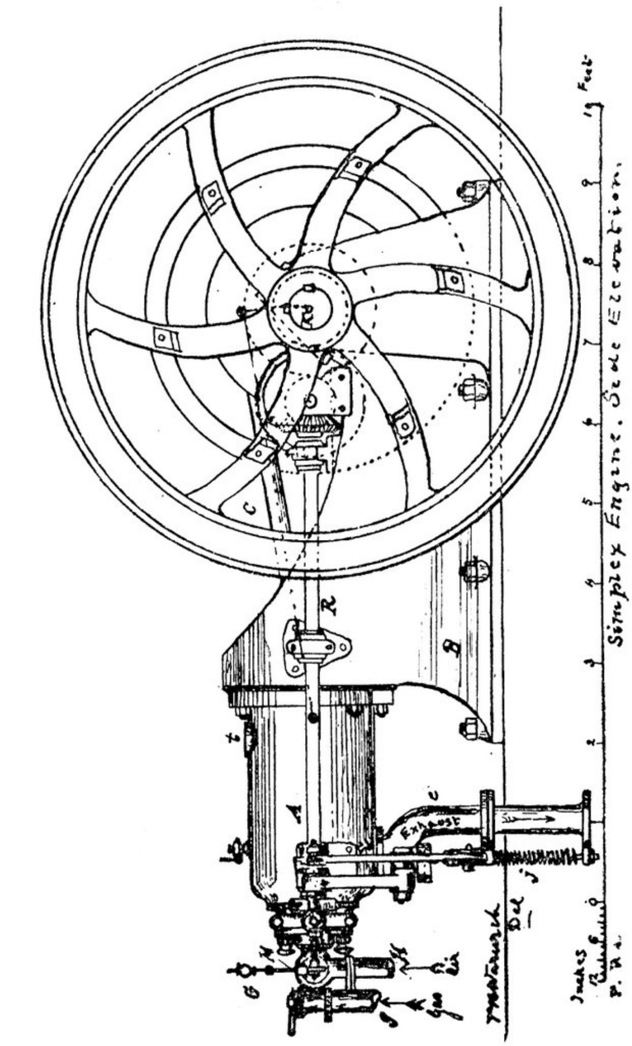



FIGURE 17.

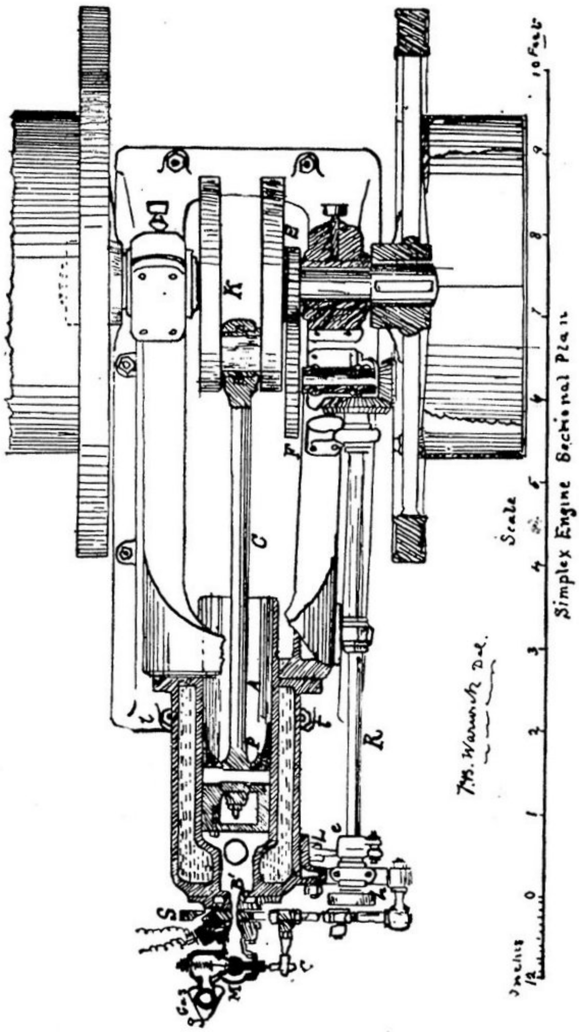



FIGURE 18.

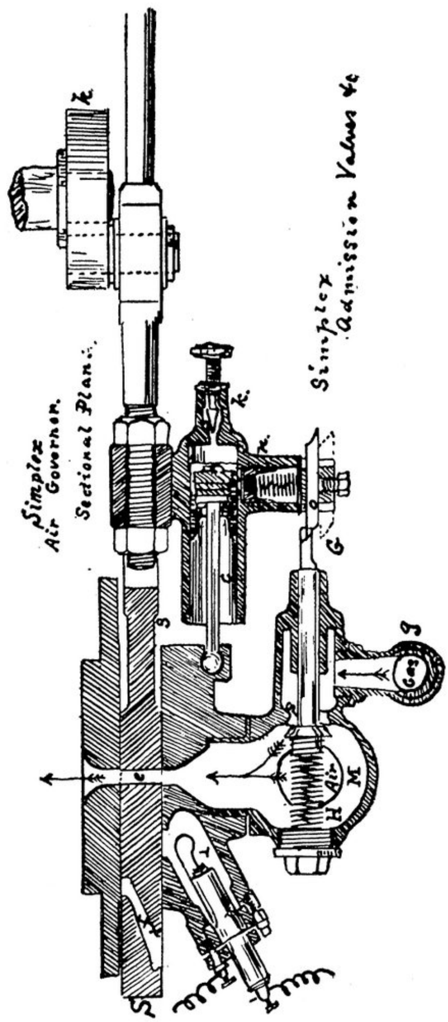

Simplex
Air Governor.
Sectional Plan.
Simplex
Admission Valves &c
Gas
Air
H
M
G

FIGURE 19.

needle valve allowing the compressed air to pass out of the air chamber. N shows the plunger valve and spring carrying on its end the trip finger o, which engages with the stem G of the poppet valve S and forcing back the spring H, allows the gas to enter the mixing chamber M.

Should the speed of engine exceed what it is

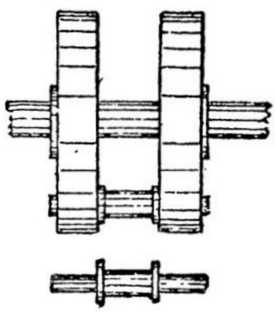


FIGURE 20.—CRANK PIN.

set for the air pump compresses air in the air chamber more rapidly than it can escape by the needle valve K, and the plunger N is forced out and the trip finger o takes the place shown by the dotted lines Fig. 19 and does *not* strike the valve stem G and the poppet valve S is held shut by spring H and an explosion missed.

The mixed and compressed gases are ignited at the proper instant by being forced down the

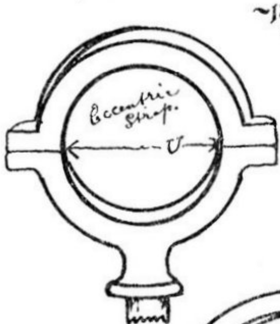
port f, into the chamber r, where a continual stream of sparks is kept up by a small induction coil, or if preferred a platinum wire may be kept white hot by a battery or the regular hot tube may be used with good results. In Fig 17 A is the cylinder with its trunk piston at P. C the connecting rod and K the cranks. The method of building up the cranks by a crank pin being shown at Fig 20.

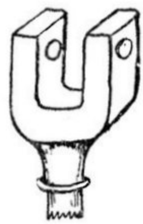
# Wadsworth-Warwick
# GAS ENGINE.

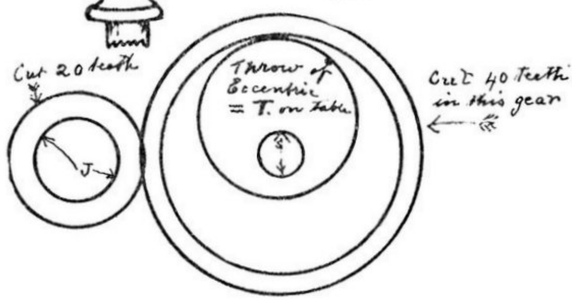
P.B. Warwick. Del.

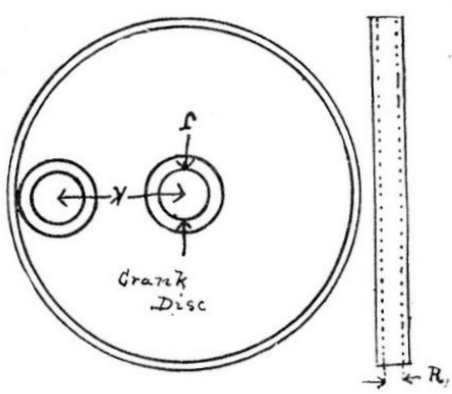


~1897~

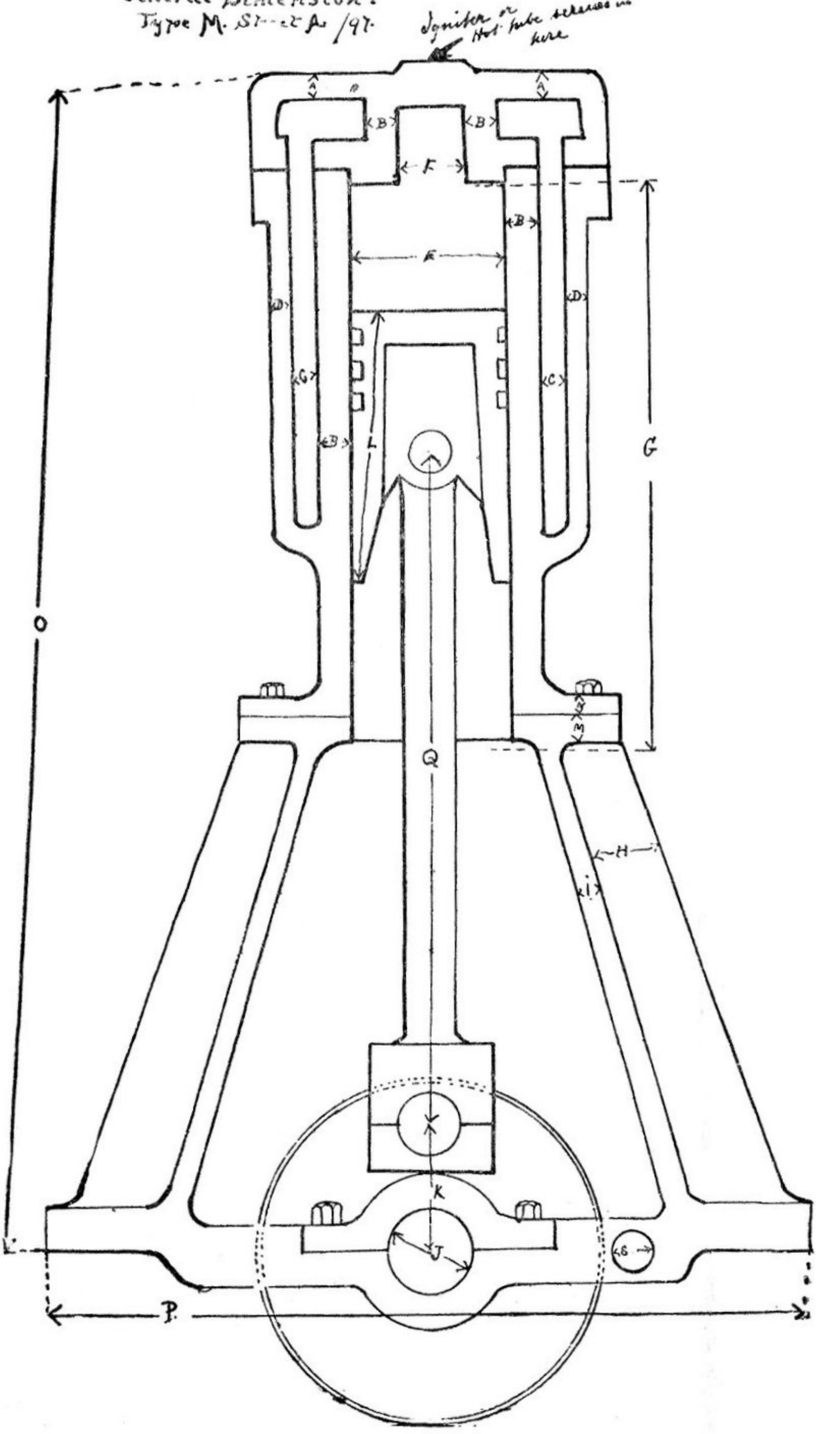




General Dimensions
Type M. Sheet A /97.



## CHAPTER VIII.

### The Fairbanks-Morse Gas and Gasoline Engine.

The Fairbanks-Morse gas and gasoline engines as shown in Fig. 21 are probably the best known of American Gas Engines, and are made in various sizes from 2 to 75 h. p. One of the principal features claimed by the makers is the simplicity of the mechanism, the number of the working parts being reduced to a minimum. Modern steam practice has been followed in placing the governor, which is located in the flywheel, thus dispensing with belts, gears, etc. The hot tube, or electric igniter, or both, is used as desired. Referring to the gasoline engine, this fluid is pumped continuously into a small brass container or reservoir on the engine, in which it is kept at a constant level. Air passing through a nozzle connected with this reservoir takes up sufficient oil to form an explosive

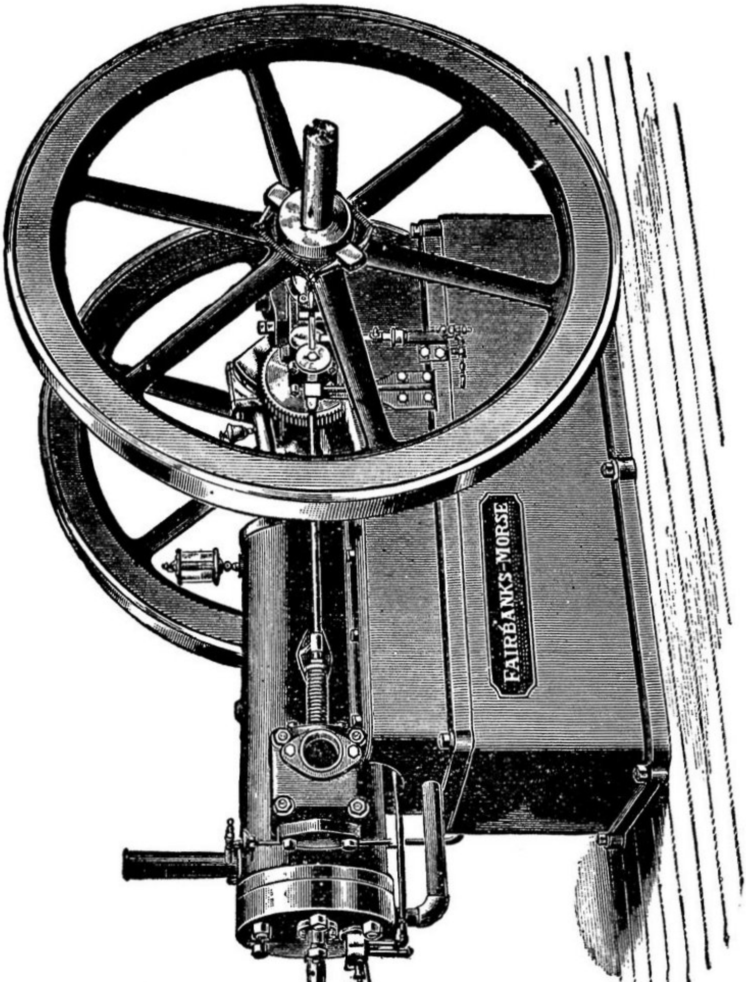



FIGURE 21.

mixture; this is regulated by the governor. When an explosion is not required, the exhaust valve is held open and no charge is admitted; and the engine is relieved of the work of compression. There are only two valves on the engine, both of which are of the poppet type and well water-jacketed. There is but one cam which works the exhaust valve through a straight rod. On all engines above 3 h. p. a self starter is fitted which is very simple in construction and works extremely well. The Fairbanks-Morse Co. have extensive works at Beloit, Wis.

This engine was originally designed for pumping in the west where irrigation is a necessity, but met with such success that its designor, Mr. Charter, who has been termed the daddy of the American gasoline engine, modified it, and under its new name it is meeting with great success, even for electric lighting, which is the most severe test that can be applied to a gas or gasoline engine. A plant is now being designed by the writer where it is intended to use several of these engines of large size for incandescent lighting. One of the noticeable features of this engine is that even in the large sizes not more than a pint of gasoline

is in the supply tank in the building at a time and the reservoir containing the main supply is in the earth below the engine and outside the building, thus doing away with any objection that the fire underwriters might have to the use of gasoline in a building. No carburetor is used, the gasoline being sprayed directly into the cylinder on the out stroke of the piston, the exhaust being closed; in other words the gasoline is inhaled into the cylinder and then compressed and afterwards exploded.

## CHAPTER IX.

### The American Otto Gas Engine.

The Otto Gas Engine, invented in 1867 by Dr. N. August Otto, and which was exhibited by him at the Paris Exhibition of the same year, and obtained a gold medal for general excellence, is manufactured in this country by The Otto Gas Engine Works of Philadelphia, Pa., who state that over 47,000 engines, representing over 250,000 h. p., have been sold and are still in use. The writer, while in the employ of Messrs. Crossley Bros., of London and Manchester, England, in 1883, set up one of the first upright or domestic Otto engines in Otto & Crossley's window on Cheapside, London, and connected it direct to a Siemens incandescent dynamo. It suffices to say that the engine and dynamo are still there, working every day lighting the offices of the concern. Messrs. Crossley Bros. have recently installed several large engines (one of 350 ind. h. p.) in Ireland for electric lighting, which is a guarantee that these engines are perfectly regular and govern very closely. A cut of this engine is shown in Figure 22.

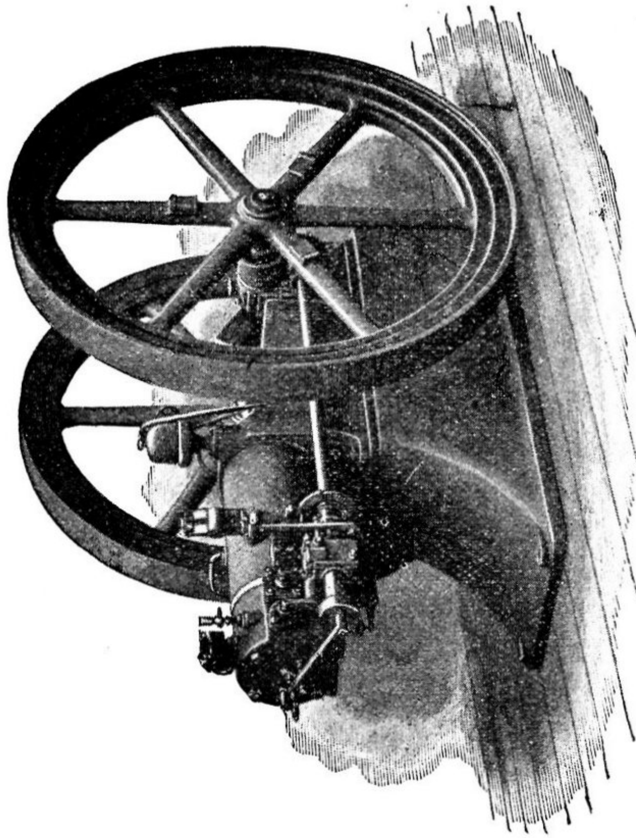


FIG. 22.—THE OTTO GAS ENGINE.

## CHAPTER X.

### How to Make a Carburetor for a Gasoline Engine.

In many places it is impossible to obtain gas to operate the engine, therefore we will consider how a carburetor can be made. While almost any method of saturating air with gasoline will do, even the crude method sometimes employed of forcing the air through the liquid giving fair results, still this is not economical, as, if the gasoline is heavy or common, only the more volatile oil will be vaporized and the balance must be thrown away. A cut is shown of a very simple carburetor by means of which even coal oil (kerosene) can be used. The apparatus consists of two parts, the heater and the carburetor, or saturator. The latter is shown at Fig. 23 in section. It is a simple cast-iron shell with a float working in an inside chamber.

1. Is the float.
2. Float tube cap.
3. Screen.
4. Plug.
5. Tube cap screw.
6. Sight glass.
7. Screw ring.
8. Drain cock.
9. Holes admitting gasoline to float.
10. Horsehair.
11. Level of gasoline.
12. Gasoline needle valve.
13. Shield.
14. Hot air inlet from heater.
15. Gas or vapor outlet.
16. Gasoline inlet from tank.

The heater is simply a chamber into which the exhaust passes on its way out to the open air, and is made by screwing two caps onto a piece of 8-inch pipe and then drilling and tapping two holes in the ends so as to allow a piece of 1-inch pipe with two elbows and a nipple on it to be placed in it to make a heating coil. This is open at one end, and the other end connects to the hot air inlet No. 14, shown in

NOTE.—The diameter of the Carburetor for a 2 or 3 h. p. engine should be 9 x 11 inches high inside measurement.

Fig. 23. The action is as follows: the piston on the out stroke draws in a mixture of gasoline gas and air. The gas is generated by the air drawn through the heater pipe being heated by

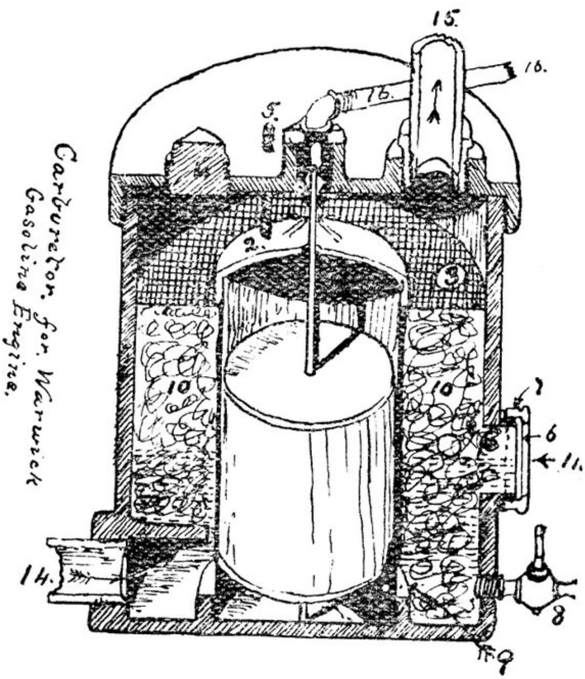



FIGURE 23.

the exhaust. This hot air, by the suction of the piston, is caused to flow in at the hot air inlet, and after bubbling through the gasoline in the carburetor passes out of the vapor outlet, 15. to the gas valve of the engine, is there compressed and exploded, and then serves to heat the air for the next charge.

## CHAPTER XI.

### How to Make a Simple Electric Igniter.

First procure a porcelain or clay wall insulating tube from any electric supply store. This should have a $\frac{3}{8}$-inch hole through the center and be about 3 inches long over all and have a $\frac{1}{2}$-inch head 1 inch in diameter. Now procure a piece of $\frac{7}{8}$-inch brass tube $1\frac{1}{2}$ inches long, and after cutting a thread on the outside of it place it over the outside of the wall tube filling up the space between with plaster of paris or asbestos cement. While this is setting, take a piece of brass rod $\frac{3}{4}$ inch in diameter and turn it down to a snug fit to the inside of tube. Make this three inches long and leave a collar on one end to prevent it going through the tube by the force of the explosion. Now turn up a collar $\frac{1}{2}$ inch by $\frac{5}{8}$ inch diameter and shrink it on to the end of the brass plug that projects through the insulating tube. Now drill a $\frac{1}{8}$-inch hole through the brass plug and this part is ready to

screw into the cylinder head where a suitable hole must be drilled and tapped to receive it. You will now require a short piece of drill rod $\frac{1}{8}$-inch in diameter and 6 inches long, cut an 8-32-inch thread onto each end of this and fit it to work nicely through the $\frac{1}{8}$-inch hole in the brass plug. When this is done a piece of round brass two inches long by one inch diameter should be screwed on to the inside end to see how it fits and then removed and a $\frac{3}{8}$ or $\frac{7}{16}$ inch hole drilled in a little way, say one inch, to receive a piece of carbon of the same size, which may be secured there by a couple of 8-32 set screws. Now obtain a piece of fiber, or better, vulcabeston, three inches long by $\frac{3}{4}$-inch wide and $\frac{1}{2}$ inch thick, drill and tap an 8-32 hole through the center and one at each end to receive the ends of the two springs which should be made out of piano wire wound on a mandrel. The igniter is now finished and ready to be assembled and screwed into the cylinder head and connected with a spark coil and battery. The action is as follows:

The piston just before the end of the up or compression stroke strikes the end of the carbon rod and pressing up the steel rod stretches the springs slightly by the momentum stored in the

fly wheels, the piston passes the dead point and starts on the down stroke, and then breaks contact with the carbon and piston head and a spark is drawn which ignites or explodes the compressed mixture, and an impulse being given to the piston the working cycle commences.

Nearly any good spark coil can be used, but a twelve inch coil such as is used for electric gas lighting is best.

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NOTE.—Our hand dynamo, price $3.50, will be much better than batteries. You will need no spark coil with it.

BUBIER PUBLISHING CO., Lynn, Mass.

## CHAPTER XII.

### The Hornsby-Akroyd Oil Engine.

This engine has one peculiarity which distinguishes it from the other types of heat motors. This is the fact that it has neither a hot tube, an electric spark nor a slide-valve with flame to explode the charge of oil and air, and is therefore, perhaps the simplest oil engine now built. A peculiar feature is that no attempt is made to vaporise the oil, or convert it into spray until it is actually injected into the combustion chamber. Hence the density of the oil is a point of no importance and heavier petroleum may be used than in most other engines. The gravity of the oil used is usually about 0.850 and its flashing point 150 degrees F., but excellent results have been obtained with oil having a specific gravity of 0.864 and a flashing test or point of 225 degrees F., thus securing perfect safety in operation. The chief objections to gas and oil engines in general is the necessity of

providing artificial means of igniting the charge. This objection is obviated in the Hornsby-Akroyd type. The manner in which the explosion is obtained in this engine is as follows: The cylinder is provided with an extension communicating with it by a relatively narrow neck. This extension is *not* water-jacketed and forms a retort in which the oil is vaporized. Nothing but oil in liquid form is injected into the retort and only air is drawn into the cylinder. This engine is shown in Figure 24.

On the out stroke of the piston air is drawn into the cylinder and oil is forced into the hot retort. At the end of the stroke there is in the retort oil vapor, which is not in itself explosive, and in the cylinder pure air which is also non-explosive, and there is not sufficient leakage from one to the other to make either charge explosive. On the return stroke of the piston, the air is forced from the cylinder through the communicating neck into the retort. For a moment the mixture of oil-vapor and air is too rich to explode, but as the piston progresses, enough air is forced in to make the mixture naturally explosive. This automatic explosion is found to take place exactly as the piston is making the next out stroke. Ignition takes

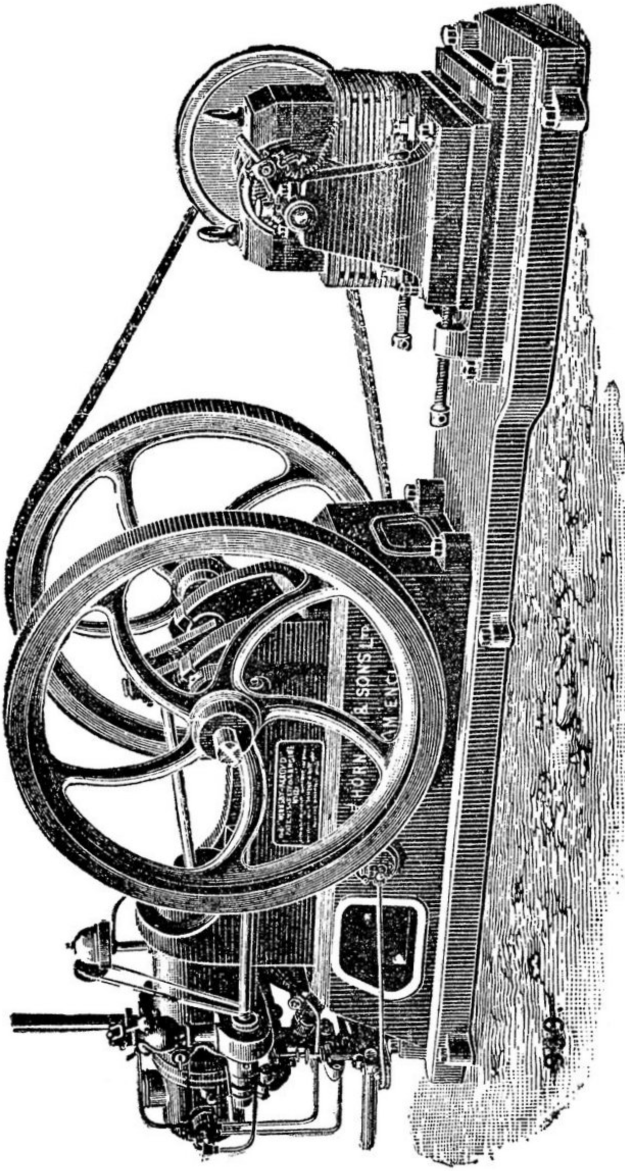

FIGURE 24.

place within the retort, the piston being protected by a layer of pure air. Analysis made of the gases indicate that the oil is completely burned in the cylinder with an excess of oxygen. The products of combustion formed consist mainly of steam and carbon dioxide diluted with nitrogen and oxygen, traces of carbon monoxide being also detected, so that the exhaust is not objectionable. The oil is sent to the retort by a small pump, which always supplies enough for the full power the engine is expected to produce. If less power is being used the speed increases a trifle, (less than 1 per cent.) and a high-speed "Porter" governor opens a by-pass and allows the surplus oil to return to a reservoir cast in the base of the engine. This engine gives first-class results and is largely used in England, but as far as the writer is aware is not yet on the American market, and knowing from actual experience in Birmingham, England, that its performance is very satisfactory, we will next describe an engine that will use any grade of oil or gasoline.

## CHAPTER XIII.

### The Birkholz or Raymond Improve Engine.

This engine is built by the T. I. Case Threshing Machine Co. of Racine, Wis. The most important feature of this engine is the method of governing employed by means of which the number of explosions is always the same, but the strength of the impulse is varied by the strength of the gas and air mixture and the quantity that is admitted. In the factory these engines are tested to 25 per cent. over their normal power with a load of incandescent lamps. A single cylinder 2 h. p. engine of this make belted direct to a Warwick 2 K. W. dynamo held the needle of a Weston volt meter so steady that it was impossible to detect a quiver.

The engine is of the Otto or 4-cycle type, which, the makers claim is the simplest and best, as the piston does all the work.

It is built in single, double or quadruple cylinders, the multiple cylinders being employed for economy of space and gas, neatness of design, and to lighten and divide the force of the explosions. The makers state that they do not depend upon multiplying the cylinders for steady power, as a single cylinder engine will regulate *almost* as closely as a quadruple one.

They consider that the vertical gas engine has many points of superiority over the horizontal type, the rocking motion being practically done away with. The vertical type also economises space, a 50-H. P. not exceeding 5x7 ft. of floor space. All sizes of engines are self-starting. This engine is also one of the few on the market provided with plugs to enable the operator to take a card off his engine with an indicator. The engine is shown in Figure 25.

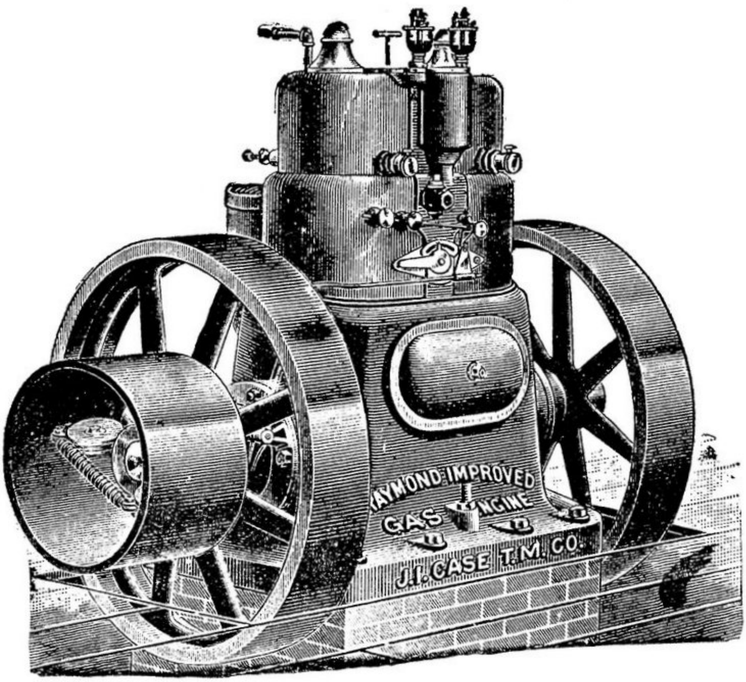


FIGURE 25.

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